# A NEW ANNUAL SPECIES OF *MINUARTIA* (CARYOPHYLLACEAE) FROM OREGON AND CALIFORNIA

ROBERT J. MEINKE
Restoration Ecology and Plant Conservation
Biology Cooperative Project,[1]
Department of Botany and Plant Pathology,
Oregon State University, Corvallis, OR 97331

PETER F. ZIKA
Herbarium, Oregon State University,
Corvallis, OR 97331

ABSTRACT

**Minuartia cismontana** is described as a new species from the lower slopes of the Cascade Mountains, Sierra Nevada, and Coast Ranges of Oregon and California. It appears most closely related to *Minuartia californica* and *M. pusilla,* as suggested by macromorphological traits and seed microsculpture. The new species is distinguished chiefly by a stiffly erect habit, elongate pedicels and internodes, narrowly attenuate and prominently nerved sepals, hyaline sepal apices, and petals that equal or only slightly exceed the calyx. The flowering phenology of *M. cismontana* is overlapped by *M. pusilla* but is normally later than *M. californica.* Extant occurrences of the new species in Oregon are known only from ultramafic substrates. The range of *M. cismontana* in California appears largely coincidental with the distribution of serpentine outcrops, based on herbarium records and geologic maps.

Recent botanical investigations of ultramafic outcrops in the North Umpqua River basin have resulted in an increased understanding of rare and localized species of southwestern Oregon (Godfrey and Callahan 1988; Fredricks 1989; Shelly 1989). During a field trip associated with one of these studies several populations of a locally common annual *Minuartia* were discovered and tentatively identified as *M. californica.* The plants deviated from published descriptions of that species, however, and were growing farther north than *M. californica* had been previously reported (Maguire 1951; Peck 1961; Munz 1968). Moreover, they were restricted to serpentine substrates, leading to speculation that they might represent another North Umpqua endemic.

Specimens of the putative new species were collected for study, including seeds that were used to cultivate plants in the greenhouse. Pressed material and live plants were compared with herbarium collections of known annual species of *Minuartia* from North America, particularly *M. californica* and *M. pusilla,* the two taxa that most

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resembled the unknowns based on the literature. It was concluded that the Oregon plants were members of an undescribed species that, rather than being a local endemic, occurs intermittently from the southern foothills of the Cascade Mountains to central California. The present paper provides a description for the new species, contrasts it with similar and potentially related taxa, and includes a key to the annual species of *Minuartia* native to western North America.

**Minuartia cismontana** Meinke and Zika, sp. nov. (Fig. 1).—TYPE: USA, Oregon, Douglas Co., gravelly serpentine meadow, Ace Williams Mountain, T26S R3W Sect. 27 NE¼, ca. 630 m, 30 May 1989, *Meinke 5757* (holotype, OSC; isotypes, CAS, MO, NY, RM, RSA, UC, US).

Plantae annuae, glabrae; *caulibus* (5–)8–20(–25) cm longis, erectis; *foliis* 2–7(–9) mm longis, 0.5–1.2(–1.8) mm latis, lance-linearibus, (1–)3-nervis; *inflorescentiis* dichotomis; *pedicellis* (7–)10–30(–35) mm longis, capillaribus; *sepalis* 3.2–5.5 mm longis, linearibus vel lanceolatis, scarioso-marginatus, 3(–5)-nervis; *petalis* 4–6.5 mm longis, oblanceolatis-cuneatis vel elliptico-oblongis; *capsulis* 3.5–5.8 mm longis, valvis 3; *seminibus* 0.7–1.0 mm longis, subreniformis, minute papillatis.

Glabrous *annual,* herbage green or reddish-purple, well-developed specimens wiry and freely branched above; *stems* erect, (5–)8–20-(–25) cm tall, dichotomously branched from near the base, with middle and upper internodes ranging from 1.5–3.5 cm long; *leaves* few, green to bluish-green, scarious-margined below, withered or often ± tenacious at the stem base, scattered and persistent along the axes, 2–7(–9) mm long, 0.5–1.2(–1.8) mm wide, lance-attenuate to linear, acute to mucronate, 1–3-nerved; *inflorescence* an open cyme; *flowers* nyctitropic; *pedicels* capillary, elongate, (7–)10–30 (–35) mm long in fruit, erect or occasionally arcuate; *sepals* 3.2–5.5 mm long, lance-linear to lanceolate, tips sharp and hyaline, colorless or rarely anthocyanic, narrowly acute to long-attenuate, scarious-margined the entire length, possessing 3(–5) prominently ridged nerves that predominate the middle chlorophyllous portion of the sepal, these especially raised at the thickened, ± squarrose base, the primary nerve extending to the hyaline apical portion, the lateral nerves nearly as long, ± immediately adjoining the scarious margins; *petals* clear white, persistent after pollination, 4–6.5 mm long, oblanceolate-cuneate to oblong-elliptic, equal to or up to ca. one-fourth (–one-third) longer than the sepals, inserted with the stamens on a thickened receptacle; *nectaries* present, alternating with the stamens on the floral disk; *styles* 3; *capsule* 3.5–5.8 mm long, ± ovoid, 3-valved, ca. equalling the length of the sepals or slightly shorter; *ovules* 15–25; *seeds* 5–15, 0.7–1.0 mm long, brown or reddish, asym-

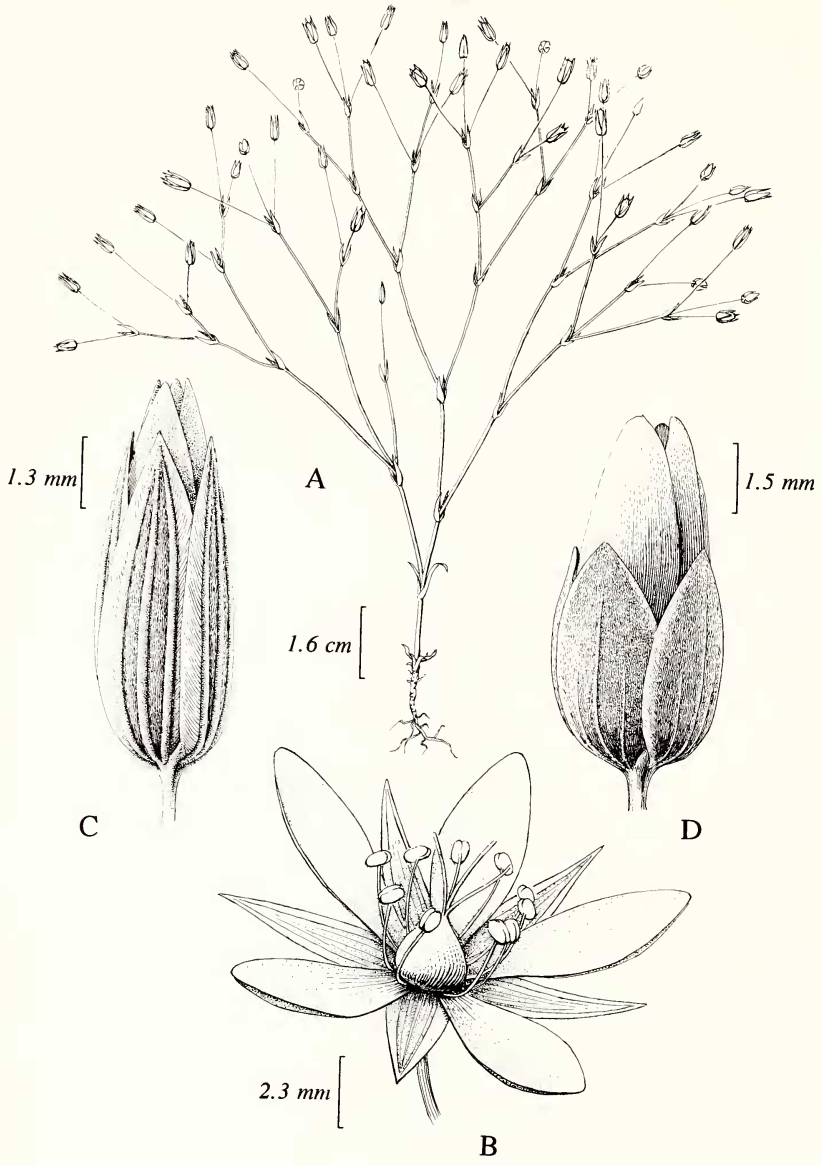



FIG. 1. *Minuartia cismontana.* A. Habit. B. Close-up of open flower. C. Close-up of closed flower, detailing petal length and sepal morphology. In extreme specimens, the ribbed nerves of the sepals become crowded and closely parallel. *Minuartia californica.* D. Close-up of closed flower.

metrically reniform with a prominent radicle, testa minutely foveolate-papillate, cell margins sinuous.

PARATYPES. USA, California: Amador Co., Hamm's (Station), 5000 ft, May 1895, *Hansen 1100* (DS, MO). Calaveras Co., Mokelumne Hill, *Blaisdell s.n.* (CAS). El Dorado Co., Armstrong's Station, 5300 ft, 13 Jun 1895, *Hansen 1100* (DS); Institute of Forest Genetics, 3 mi E of Placerville, 2500 ft, 28 Apr 1943, *Robbins 1043* (CAS); 2 mi W of Georgetown, on road to Greenwood, 28 Apr 1956, *Raven and Robbins 9077* (CAS); E slopes of Bass Lake, 2 mi NE of Clarksville, 21 May 1959, *Crampton* 5252 (AHUC). Humboldt Co., Kneeland Prairie, 2500 ft, 4 May 1913, *Tracy 4068* (WTU, US), 30 May 1921, *Tracy 5479* (UC, WS, POM); Trinity River Valley, near Willow Creek, 500 ft, 30 Apr 1922, *Tracy 5991* (UC); McClellan Mountain, 2700 ft, 30 May 1925, *Tracy 7040* (UC); Laribee Valley, 25 May 1930, *Parks and Tracy 866* (NY, CAS, DS, MO, UC, RSA); ridge top near Harris, 3000 ft, 13 Jun 1948, *Tracy 18055* (WTU, UTC). Lake Co., near Lakeport, 12 May 1903, *Baker 2957* (US, POM, MO, RM, UC, JEPS [on UC 75355]); Jordan Park, 1 May 1932, *Jussell s.n.* (POM); near Lakeport, 23 May 1933, *Henderson 15238* (ORE). Mendocino Co., Tomki Road, 11 km N of Calpella, 550 m, 26 May 1981, *Smith 6410* (HSC). Merced Co., 5 mi N of Snelling, 4 May 1937, *Hoover 2055* (UC). Monterey Co., Santa Lucia Mountains SW of Junipero Serra Peak, 2300 ft, 13 May 1980, *Ertter and Strachan 3377* (CAS, WTU, UTC, RM, RSA, NY). Placer Co., E end of Ralston Ridge (T14N R13E Sect. 28), 5100 ft, 28 May 1978, *Stebbins 7895* (CAS). San Francisco Co., Lake Merced, 26 Apr 1895, *Cannon s.n.* (CAS). San Luis Obispo Co., 3.2 mi NE of Highland School, 1500 ft, 26 Apr 1937, *Hendrix 98* (UC, RSA); Yazo Creek district, N of Pozo, 20 Apr 1947, *Hoover 6990* (DS, CAS, SD, RSA); road between El Dorado School and Pozo, 7 mi N of Pozo, 25 May 1955, *Ferris 12836* (DS, WTU, RSA); N Traffic Way, Atascadero, 20 Apr 1958, *Hardman 3055* (CAS, SBBG); hills between the San Juan River and the Carissa Plains, 28 Apr 1958, *Hardman 3136* (POM); Bee Rock Canyon, 12 May 1960, *Bacigalupi 7429* (RM, WTU, UTC). Tehama Co., 9 mi E of Paynes Creek, 3300 ft, 12 May 1954, *Barneby and Howell 11484* (CAS). Trinity Co., Weaverville, 3400 ft, 30 May 1880, *Kleeburger s.n.* (CAS). Oregon: Douglas Co., Umpqua Valley, Apr 1881, *Howell s.n.* (ORE); Oakland, Apr 1881, *Howell s.n.* (NY); along BLM Road 13.0 in T28S R4W Sect. 1, 23 Jun 1978, *Crowder 440* (BLM—Roseburg District); NE of Watson Mountain, above Douglas Co. Road 17, 1200 ft, 10 Jun 1984, *Fredricks 263* (OSC); type locality, 29 Apr 1987, *Zika and Holmes 10216* (BLM—Roseburg District); Beatty Creek Research Natural Area, T30S R6W Sect. 19, 1200 ft, 5 Jun 1987, *Hopkins 1448* (Douglas County Museum). Lane Co., near Eugene, 2 May 1925, *Constance s.n.* (DS); Lorane Road, 11 May

1930, *Henderson 12258* (ORE), 17 May 1931, *Henderson 13540* (UC); Crowe Road, Jun 1933, *Henderson 15182* (DS).

## Taxonomic Relationships

*Vegetative and floral morphology.* Previous collections of *Minuartia cismontana* have usually been identified as *M. pusilla* or *M. californica* and both of these taxa bear a resemblance to the new species. While *M. cismontana* has floral dimensions reminiscent of *M. californica,* it could be best described as a larger, open-flowered version of the poorly known *M. pusilla,* an inconspicuous and apparently autogamous species with which it shares the consistently lance-linear, attenuate sepals and elongate pedicels and internodes. Sepals of *Minuartia cismontana* are distinctive in combining a sharp, narrow, hyaline sepal apex with a prominently tri-nerved, chlorophyllous center; the species is also unique in having petals that equal or only slightly exceed the calyx (Fig. 1B, C).

*Minuartia cismontana* plants have capillary, often wiry stems and branches (Fig. 1A) and are typically several times larger than *M. pusilla.* The stiffly dichotomous branching of the new species is a prominent feature in mature specimens not stunted by drought. The diminutive *M. pusilla* differs further in having petals that are considerably shorter than the small calyx (or absent) and single-nerved sepals and leaves. *Minuartia californica* is decidedly polymorphic. However, most examples of this species also tend to be smaller than *M. cismontana,* even when apparently well-watered, and typically possess blunt, inconspicuously nerved sepals that invariably have pigmented, non-hyaline tips (Fig. 1D). Although *M. californica* is described as having rounded, obtuse, or "acutish" sepals (Maguire 1951; Peck 1961; Munz 1968), a few, mostly depauperate individuals have been collected with narrowly acuminate calyx segments, particularly near the southern Sierra Nevada and along the central California coast. These plants are distinguished from *M. cismontana* by the corolla length, which surpasses the calyx by one-half or more, the relatively small sepals that rarely exceed 3 mm and lack a hyaline tip, and a diffuse habit less than 7 cm high.

*Minuartia cismontana* might also be mistaken for *M. douglasii* and occasionally co-occurs with this species. *Minuartia douglasii* is recognized by glandular pubescence (which is sometimes sparse), broadly ovate sepals, and flexible, linear leaves up to 25 mm long. It has wafer-like, prominently wing-margined seeds (Fig. 6), an unusual trait for the genus that suggests *M. douglasii* is not a particularly close relative of *M. cismontana. Minuartia tenella* (=*M. stricta* var. *puberulenta*), an annual or short-lived perennial of mesic sites in the Pacific Northwest, has acuminate sepals and petal length comparable to *M. cismontana.* It can be distinguished by a glandular-pubescent inflorescence and conspicuous axillary leaves.

TABLE 1. MORPHOLOGICAL CHARACTERS USED IN PRINCIPAL COMPONENTS ANALYSIS OF *Minuartia cismontana* AND *M. californica*. Sixteen populations of *M. cismontana* and 32 populations of *M. californica* were sampled. The numbers following each trait indicate the sample size used to calculate an average score for each population. See discussion in text.

1. Sepal length (10).
2. Ratio of sepal length to petal length (10).
3. Length of internode beyond first stem branch (10).
4. Post-anthesis pedicel length (10).
5. Plant height (2).
6. Ratio of sepal length to capsule length (10).
7. Capsule length (10).
8. Style length (10).
9. Length of leaf at first stem branch (10).
10. Sepal length to width ratio (10).
11. Length of basal stem prior to first branch (2).
12. Ratio of lateral sepal nerve length to primary nerve length (10).
13. Width of scarious sepal margin (10).
14. Shape of sepal tip (1 = long-attenuate or acuminate; 2 = acute; 3 = obtuse to rounded) (10).
15. Shape of cauline leaf tip (1 = acute; 2 = mucronate; 3 = obtuse) (10).

*Phenetic analysis. Minuartia cismontana* is most often confused with *M. californica* and will generally key to this species using most floristic references. To evaluate the morphological relationship of these taxa a principal components analysis (PCA) of 48 populations was conducted, using 15 vegetative and floral attributes commonly employed in *Minuartia* taxonomy (Table 1). Sixteen collections of *M. cismontana* and 32 of *M. californica* were included, selected from across the range of both species. Each population sample was represented by a single herbarium sheet having a minimum of two complete specimens.

The selected morphological traits were measured for each population and the taxa ordinated along the axes of the first two principal components. The resulting PCA diagram (Fig. 2), describing 57.4% of the variation contained in the original data set, clearly indicates that *M. cismontana* and *M. californica* are separable phenetically on the basis of the traits used in the analysis. Characters heavily (and more or less equivalently) weighted along the first axis are 1) the ratio of lateral sepal nerve length to primary nerve length; 2) the ratio of sepal to petal length; 3) plant height; and 4) post-anthesis pedicel length. This confirms the value of sepal, pedicel, and stem measurements in classifying collections of the two species.

*Seed morphology.* Seed coat microsculpture and seed shape, conservative traits successfully used in the taxonomy of *Minuartia* (Wofford 1981), are in agreement with a proposed alliance of *M. cismontana, M. pusilla,* and *M. californica.* Seeds of the three species are unequally reniform and foveolate-papillate (Figs. 3–5), often with

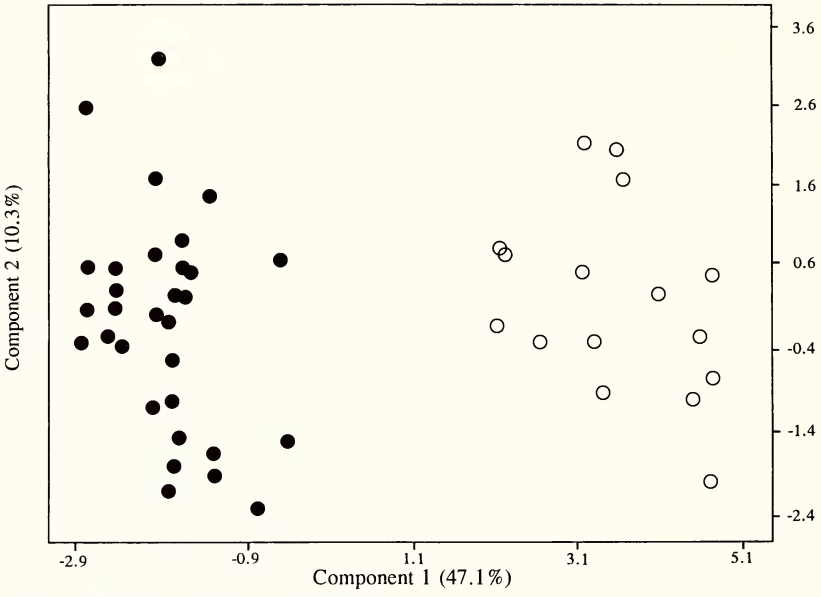
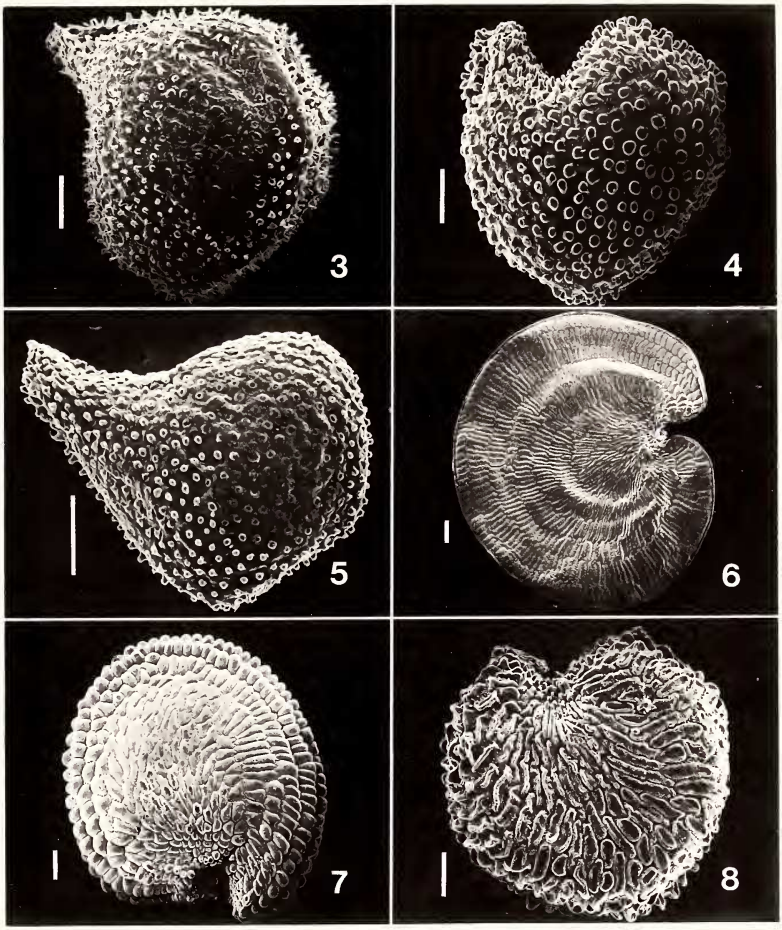



FIG. 2. Plot of the first two principal components resulting from the phenetic analysis of 15 morphological traits (Table 1) of *Minuartia cismontana* and *M. californica*. Open circles = *M. cismontana*; solid circles = *M. californica*. The first axis depicts 47.1% and the second 10.3% of the variation represented in the original data set. See discussion in text.

a prominent radicle. They are commonly angled on the edges due to being pressed together in the capsule but are usually terete and never significantly flattened. Those of *M. californica* appear to be distinctive in having fewer, and notably larger, testal processes. The seeds of the other annual *Minuartia* in western North America are readily distinguished from the preceding three species, being broadly reniform to somewhat asymmetric and lacking tubercles (Figs. 6–8). They are more or less lenticulate and range from moderately to severely compressed.

*Reproduction and phenology.* Seeds of *Minuartia cismontana* collected at the type locality were dormant when capsules dehisced. They germinated readily at room temperature after undergoing moist, dark stratification for three to eight weeks at 2–3°C. It is not known how the germination ecology of *M. cismontana* compares with related species.

Observations of field and cultivated *Minuartia cismontana* plants suggest that the species is a facultative outcrosser. Flowers open on sunny days and attract small flies and bees to the nectar glands located along the receptacle. Nectar droplets accumulated in flowers




FIGS. 3–8. Scanning electron micrographs of seeds of annual *Minuartia* species from western North America (scale bars = 0.2 mm). 3. *M. cismontana.* 4. *M. californica.* 5. *M. pusilla.* 6. *M. douglasii.* 7. *M. howellii.* 8. *M. tenella.*

of greenhouse grown plants and were evident to the unaided eye. Anthers dehisce one to two days after anthesis, at which time self-pollination may occur when corollas close during the evening. Seeds were produced by *M. cismontana* plants in the greenhouse, indicating that the species is genetically self-compatible.

The tiny flowers of *Minuartia pusilla* are probably exclusively self-pollinated since they lack nectar glands and occasionally petals, and their anthers open prior to floral expansion. The chasmogamous-flowered *M. californica* may have a breeding system similar to that postulated for *M. cismontana* but there was no opportunity to ex-

amine living plants of this species. Inspection of herbarium material of *M. californica* shows that flowers preserved shortly after opening often have undehisced anthers.

*Minuartia cismontana* blooms from late April through mid-June, depending on elevation and latitude. This contrasts with *M. californica,* which usually flowers from late February to mid-April, or occasionally into early May. *Minuartia pusilla* has been collected in flower from April through July. All three species are strict ephemerals, their germination and longevity greatly dependent on precipitation before and during the growing season.

*Distribution and habitat. Minuartia cismontana* is known from Douglas County, in southwestern Oregon, south to at least the vicinity of San Luis Obispo in central California. Historical collections place *M. cismontana* as far north as Lane County, Oregon, south of Eugene near the Douglas County line. Populations are widely but sporadically distributed and have been recorded from the west slope of the southern Cascade Range in Oregon, the southern Oregon Coast Range, the west slope of the north-central Sierra Nevada, and in or near the southern and northern Coast Ranges of California. The relative distributions of *Minuartia cismontana, M. californica,* and *M. pusilla* in Oregon and California are mapped in Figure 9.

Reported elevations for *Minuartia cismontana* extend from (150–) 400–1700 m. Low elevation sites (below 500 m) generally exist at the northern end of the range, mostly beyond the geographic limits of *M. californica.* Two unusual lower elevation collections of *M. cismontana,* from San Francisco and Merced counties, California, are mixed with specimens of *M. californica* on the same herbarium sheet. These are the only accounts of potential sympatry between the species. Scrutiny of the San Francisco County material, however, shows that the *M. cismontana* plants were infected with a mold while those of *M. californica* were not. This implies differences in the storage times for the two species prior to pressing, suggesting they may have actually been collected at different localities. Label data for both the San Francisco and Merced County collections are sparse and lack significant habitat information and precise elevations.

*Minuartia cismontana* frequents vernally moist slopes and ridges,

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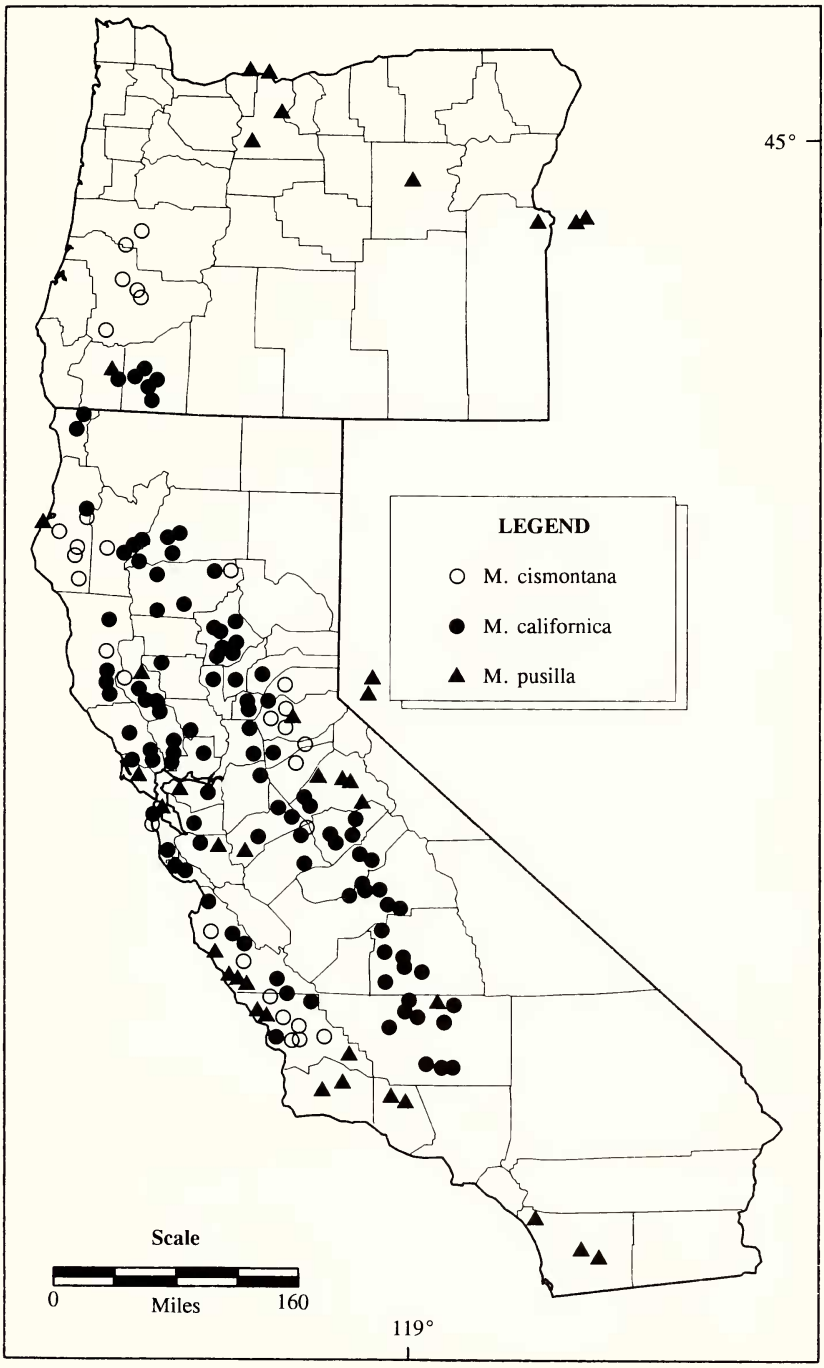
FIG. 9. Distribution of *Minuartia cismontana, M. californica,* and *M. pusilla* in Oregon and California, based on herbarium data. Each symbol may represent one or more populations. *Minuartia cismontana* and *M. californica* are endemic to Oregon and California. The range of *M. pusilla* includes a few scattered stations in the Great Basin, not all of which are shown here.


45°
LEGEND
M. cismontana
M. californica
M. pusilla
Scale
0
Miles
160
119°

apparently in well-drained microsites subject to extended drought by late spring or early summer. It is typically a foothill to low montane species, occurring in or near dry woodland or chaparral. In Oregon, common associates include *Agoseris heterophylla, Alchemilla occidentalis, Allium parvum, Calochortus tolmiei, Cerastium arvense, Epilobium minutum, Minuartia douglasii, Sagina occidentalis,* and *Silene hookeri,* as well as the rare endemics *Calochortus umpquaensis* and *Phacelia capitata. Minuartia californica* is primarily a lowland species, found throughout the Central Valley and adjacent areas of California, then irregularly north to the Rogue and Illinois River valleys of extreme southern Oregon. Recorded habitats include vernal pools, rocky fields, roadsides, and grassy slopes, occasionally on serpentine. Although the geographic ranges of *M. cismontana* and *M. californica* coincide to some extent, particularly towards the Pacific Coast, populations of the two species are generally separated by elevation and phenology in areas of apparent overlap, with *M. californica* mostly occurring below 650 m and senescing by early May. *Minuartia californica* is occasionally reported up to ca. 1400 m, but this is limited to a few localities in the southern Sierra Nevada, from Fresno County south. *Minuartia pusilla* has a broader distribution, ranging through much of California and Oregon into Washington, Idaho, Nevada, and southwestern Utah. It is infrequently recorded and occurs in a variety of primarily xeric habitats, often in waste areas or otherwise sterile sites.

In Oregon, extant populations of *Minuartia cismontana* occur only on serpentine outcrops. Herbarium labels confirm that some of the California populations are from serpentine as well, or suggest such an affiliation by describing topography and substrata consistent with serpentine landscapes. Additional circumstantial evidence supporting an ultramafic association for the new species is derived from its geographic pattern in California (Fig. 9). The range of *M. cismontana* largely coincides with the general distribution of serpentine as recorded on geologic maps (Kruckeberg 1984), both in the Coast Ranges and the Sierra Nevada foothills. It is interesting that many of the sites for the new species appear to correlate with comparatively minor ultramafic outcrops, and that no populations have been recorded from the botanically rich and heavily collected Klamath-Siskiyou serpentines.

*Conclusions. Minuartia cismontana* has been overlooked as a distinct taxon since it was first collected in 1880. The scattered occurrence of the new species and its similarity to the variable *Minuartia californica* probably has contributed to this. Morphological evidence also suggests an affinity between *M. cismontana* and *M. pusilla.* On the basis of floral, seed, and phenological characters, these species may be the most closely related of the trio. Further study is required

to evaluate this, and to estimate the relationships of *M. cismontana* and its annual relatives with perennial members of the genus. Although apparently not rare in California, *M. cismontana* is uncommon and local in Oregon, and may merit designation as a sensitive species in that state.

## Key to Annual Species of *Minuartia* in Western North America

a. Plants glandular-pubescent above; cauline leaves (5–)10–30 mm long; seeds + flattened, reniform and often lenticular, lacking a prominent radicle, tessellate to crested, never papillate
  b. Sepals ovate, acute to obtuse; cauline leaves simple or with reduced axillary fascicles; from southwest Oregon to northern Baja California, mostly away from the immediate coast
    c. Leaves and sepals evidently 3-nerved; petals broad, obovate; stems greenish; seeds flat, smooth, broadly winged; widespread ..... *M. douglasii* (Fenzlex Torr. & Gray) Mattf.
    c′. Leaves and sepals obscurely nerved, or lacking nerves altogether; petals oblong; stems reddish; seeds not strongly flattened, never winged, with crested cell margins; local in Josephine County, Oregon and Del Norte County, California ..... *M. howellii* (S. Wats.) Mattf.
  b′. Sepals lance-attenuate; cauline leaves prominently fasciculate; often coastal, from central Oregon north to British Columbia ... *M. tenella* (Nutt.) Mattf.
a′. Plants glabrous throughout; cauline leaves 3–8(–10) mm long; seeds terete, sometimes with angled edges, not flat or lenticular, asymmetrically reniform with a prominent hooked radicle, distinctly papillate
  d. Petals inconspicuous, < sepals or absent; plants dwarf, rarely > 5 cm in height; leaves and sepals generally with a single, often faint nerve; a widespread species, usually in dry habitats ..... *M. pusilla* (S. Wats.) Mattf.
  d′. Petals conspicuous, ≥ the sepals; plants (3–)5–25 cm tall; leaves and sepals prominently to obscurely 3-nerved
    e. Petals exceeding calyx by ≥ one-half; sepals green-tipped, obtuse to weakly acute or occasionally ± acuminate, faintly 3-nerved, the lateral nerves or ribs often obscured, rarely extending to the apex, separated from the scarious border by a strip of green tissue; longest fruiting pedicels 5–15(–20) mm long; flowering mostly March to April *M. californica* (Gray) Mattf.
    e′. Petals equal to or exceeding the calyx by about one-fourth; sepals sharply hyaline tipped, narrowly acute to usually attenuate, boldly 3(–5) nerved, the dorsal ribs raised and ± crowded, parallel below and converging near the apex, the lateral nerves bordering the scarious margin; fruiting pedicels (7–)10–30(–35) mm long; flowering mostly May to early June ..... *M. cismontana* Meinke & Zika

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